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Research Paper

Factor-based tactical bond allocation and interest rate risk management

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ABSTRACT

This paper offers two composite bond market factor investment strategies each for the Swiss bond market and for the global sovereign bond market. These composite factor strategies can be useful tools when making tactical asset allocation decisions between bonds and cash, and they can act as a base for the duration debate. As such, the output of our bond market factors can guide tactical interest rate views and therefore interest rate risk management. To construct these composite factors, we use four economically meaningful individual factors. Following an investment strategy based on a composite bond market factor, constructed as the equally weighted average of individual components, we are able to outperform cash as well as the static buy-and-hold strategy with regard to the Sharpe ratio, annualized standard deviation and maximum drawdown. Testing the composite and individual factors on their performance during periods of historical rising interest rates, we observe improved drawdown results compared with holding the underlying asset passively.

Keywords: asset allocation; duration; interest rate risk; sovereign bond market; risk management; factor strategy.

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1 INTRODUCTION

This paper tackles two major issues faced by asset allocation committees when determining how to position in the sovereign bond market. By creating trading signals based on a factor strategy, we are told (1) whether we should be invested in bonds at all, as opposed to holding cash (or vice versa); and (2) whether, if we are invested in bonds, we should be positioned in short-duration or long-duration bonds. To obtain trading signals for each market, we select four factors, which are combined to form a composite bond market factor strategy. The factors used in this paper are based on existing financial research and as such are no novelty. However, we show that a selection of economically meaningful factors, which are already present in the financial literature, help us to improve our investment performance – relative to being passively invested as a buy-and-hold investor – by following a systematic yet simple approach.

An additional benefit of having a factor model to indicate the optimal positioning is that it reduces poor decision making caused by human biases. As bond market investors are primarily interested in whether yields are going to rise or fall in the near future, we aim to develop a model that predicts the future development of excess bond returns over cash. Since the aftermath of the financial crisis, interest rates have experienced new lows, sometimes even negative values, and fears of an inverse term structure have arisen. This "new bond market environment" – with record low yields, strong interventions by central banks, and well-performing and highly supported stock markets backed by convincingly strong economic fundamentals – makes it more difficult and riskier to invest in bonds, as central banks have to normalize their monetary policies at some point, which would imply higher yields and therefore falling bond prices. It is therefore our objective to develop a bond market factor strategy that, historically, would have performed well when interest rates were raised.

We conduct our empirical analysis on data from various countries. In the main paper, we report the results for Switzerland and for the world as a whole. Additional results – for the United States, Germany, Japan, the United Kingdom, Australia and Canada – can be found in our online appendix, which is available upon request. Our paper is split into a theoretical part and an empirical part. The former starts with Section 2, where we explain our four factors and how we construct the bond market factor. This is followed by Section 3, in which we show how the performance metrics used in the empirical part are calculated. Section 4 contains a description of the data set used in our empirical analysis along with additional information on how we chose which data series to use for the Swiss and global cases. As for the empirical part of this paper, we report the backtesting results in Section 5; we also formally describe how the investment strategies are set up. After providing the empirical results of our market-timing and duration-switching investment strategies, we discuss their drawdown behavior in Section 6. Here, we focus on the improvements in drawdowns experienced relative to the buy-and-hold strategy in periods of rising interest rates in order to proxy these bond market factors' behavior during the imminent tightening of monetary policy. We conclude our paper with a short summary of our main results in Section 8.

2 BOND MARKET FACTOR

In this section, we introduce the underlying model of our bond market factor. First, we start with the four findings that we are trying to exploit in our bond market factor strategy. Applied financial research in particular (see, for example, JP Morgan's study by Kolanovic *et al* (2018) or Morgan Stanley's study by Hornbach *et al* (2015)) states that excess bond returns are high if

(1) carry is high and the yield curve is steep,

(2) previous bond returns have been positive,

(3) previous equity returns have been low or negative,

(4) the business cycle is slowing and/or surprises have been negative.

Based on the above observations, we develop the individual factors and describe how they are constructed, how we can adjust the signals and how these individual factors are used to build a composite factor. To do so, we follow the approach of Hornbach *et al* (2015). As the goal of the model is to determine the trade-off between cash and bonds as well as between short-duration and long-duration bonds, the factors used to build our bond market factor strategy are based on variables that have been proven to have predictive value in generating excess bond returns over cash in the existing literature. To exploit the aforementioned regularities of excess bond returns, we construct carry, bond market momentum, equity market performance and business cycle factors. While the first two factors – carry and bond market momentum – have their foundation in the bond markets themselves, the last two have their rationale in risk-off behavior, where investors typically shift from risky assets such as equities into less risky assets such as sovereign bonds once economic conditions deteriorate. While these four factors are economically reasonable, as a group they combine macroeconomic and style factors. We use both types of factor, as each has distinct characteristics in different market environments. We therefore expect to improve the combined signal by synthesizing them.

2.1 Carry

Our carry strategy's goal is to harvest the term premium resulting from a steep yield curve. For this to be profitable, the realized yield has to be lower than the initial forward yield, which, in turn, implies rising bond prices (see, for example, Korapaty and Thakkar 2018). The expectations hypothesis is used to forecast future short-term interest rates based on current long-term interest rates; it implies that carry strategies should not be successful, as the forward yields are taken to be the market's expectation of future yields. However, Fama (1976), among others, shows that forward yields predict future spot rates badly. A steeper yield curve implies higher carry and therefore higher excess bond returns (see, for example, Mueller-Glissmann *et al* 2018). The signal indicating a favorable environment is calculated as a growing full-sample z-score of the 10–2-year treasury yield curve, adjusted for volatility by dividing it by the one-year realized volatility.[1] Using a rescaled logistic sigmoid function, we normalize the signal to cap its strength when it reaches extreme values.[2] The value of the signal is bound to be in the range of ± 10. This normalization prevents the signal from reaching values that are too extreme.

2.2 Bond market momentum

Trend-following and momentum strategies are documented in various studies for different asset classes (see, among others, Jegadeesh and Titman 1993), and we therefore also include the momentum factor as one of the individual factors of our composite bond market factor. We calculate our bond market momentum factor as the difference between the excess return at $t - 1$ and an exponential moving average with a lookback period of four months. This differential is divided by volatility with the same lookback period. To prevent us from removing long-term trends in the data, we normalize the signal to the ± 10 span directly.

2.3 Equity market performance

As, among others, Ilmanen (1995) documents, risk aversion is strongly dependent on an investor's wealth. Therefore, as risk aversion can change with changing wealth, so can the observed risk premiums. With declining wealth, investors demand a higher premium for holding risky assets. To protect their wealth against potential losses, investors simultaneously accept a lower rate of return from a safer asset. Investors are therefore willing to shift into less risky sovereign bonds if risk aversion rises due to a correction or crash in the stock market. We construct a full sample z-score

[1] $(x_{1:t,T} - \varnothing(x_{1:t,T}))/\sigma(x_{1:t,T})$, where x is the data series with $t = 1, 2, \dots, T$.
[2] We use the hyperbolic tangent function (tanh function) to rescale the output to ± 10. The logistic sigmoid function is $g(x) = \mathrm{e}^x/(1 + \mathrm{e}^x)$, where tanh is defined as $\tanh(x) = 2g(2x) - 1$.

signal that is based on local equity returns with a lookback period of three months. We extend this signal with the z-score of the equity market performance difference between emerging and developed markets. We use this extension as a complement, because if risky assets perform strongly, emerging market equities tend to outperform developed market equities, and vice versa. The final signal is a simple average of both signals, again fitted into the ± 10 span using the logistic sigmoid function.

2.4 Business cycle

Fama and French (1989) find that the variation of the term spread is linked to changes in the business cycle. Typically, business cycle troughs and the steepest point of the yield curve are observed simultaneously. This also implies high bond returns as business conditions worsen, while bonds normally suffer in a strong macroeconomic environment (see, for example, Normand 2017). The business cycle factor is therefore a contra-indicator; this means that, if business conditions surprise positively, we reduce our bond exposure, increasing it if conditions worsen. As in Section 2.2, we allow for trends in the data.

2.5 Composite factors: collection and overall

Albeit we have four signals resulting from our individual factor strategies described above, we prefer to have one composite signal that indicates how to position in the bond markets. To do so, we calculate the "collection" factor, which is the simple average of the four individual factors: carry, bond market momentum, equity market performance and business cycle. In contrast to the collection signal, the "overall" signal is truncated around a centered value, where the signal is considered to be weak and unconvincing. In our case, the overall signal is set to zero if the collection signal shows only a little conviction, which we define as a signal strength of ± 1.5. Therefore, the overall factor is more restrictive in terms of signal validity, gives fewer signals and, therefore, allows less aggressive positioning than the collection factor does. We use the factor names collection and overall and, respectively, the more descriptive names untruncated and truncated bond market factor strategy, interchangeably.

3 PERFORMANCE EVALUATION

To compare the empirical results of our backtests, we evaluate the performance of our investment strategies using different metrics. While the focus of our analysis is on the standard industry performance metrics – including the Sharpe ratio, annualized return and volatility as well as maximum drawdown – we also report on a variety of additional ratios.

3.1 Sharpe ratio

The Sharpe ratio is defined as the strategy's mean of excess returns over the risk-free asset, $\overline{(R_{\mathrm{P}} - R_{\mathrm{rf}})}$, divided by its standard deviation, $\sqrt{\operatorname{var}(R_{\mathrm{P}} - R_{\mathrm{rf}})}$. We set the risk-free return equal to zero:

$$\text{Sharpe ratio} = \frac{\overline{(R_{\mathrm{P}} - R_{\mathrm{rf}})}}{\sqrt{\operatorname{var}(R_{\mathrm{P}} - R_{\mathrm{rf}})}}. \tag{3.1}$$

3.2 Maximum drawdown

Maximum drawdown is defined as the largest drop from peak to trough over a certain period of time, $[0, T]$. Mathematically speaking, if $v_t(x)$ is the net asset value of a trading strategy at time t, the drawdown function at time t is defined as the difference between the maximum of this function and the value of this function at time t. From the drawdown function, the maximum drawdown can be determined by choosing the function's maximum value over the entire time interval, $[0, T]$:

$$\text{maximum drawdown} = \max_{0 \leqslant t \leqslant T} \left(\frac{\max_{0 \leqslant \tau \leqslant t}[v_\tau(x)] - v_t(x)}{\max_{0 \leqslant \tau \leqslant t}[v_\tau(x)]} \right)(-1). \tag{3.2}$$

3.3 Sortino ratio

In contrast to the Sharpe ratio, which is based on volatility, the ratio defined in Sortino and Price (1994) focuses on downside risk. This type of risk, downside deviation in our case, ignores positive returns and instead uses the minimum acceptable return (MAR) to capture a performance lower than this minimum threshold. To calculate downside risk, we calculate the square of the difference of all returns smaller than the MAR to the MAR itself and divide this value by the number of returns, n. We set $\text{MAR} = 0\%$:

$$\text{Sortino ratio} = \frac{\overline{R_{\mathrm{P}} - \text{MAR}}}{\sqrt{\sum_{t=1}^{n}(\min[(R_{\mathrm{P},t} - \text{MAR}), 0]^2/n)}}. \tag{3.3}$$

3.4 Bernardo and Ledoit ratio

The Bernardo and Ledoit ratio is defined as the sum of positive returns divided by the sum of negative returns (see Bernardo and Ledoit 2000):

$$\text{Bernardo and Ledoit ratio} = \frac{(1/n)\sum_{t=1}^{n}\max(R_t, 0)}{(1/n)\sum_{t=1}^{n}\max(-R_t, 0)}. \tag{3.4}$$

TABLE 1 Underlying bond price and return data.

Series name	Region	Currency	First date
Citigroup GBI Switzerland 3–5 year	Switzerland	CHF	April 30, 1999
Citigroup GBI Switzerland 7–10 year	Switzerland	CHF	April 30, 1999
Citigroup WGBI 7–10 year	World	USD	June 2, 1994

The principal and total return series used for our empirical analysis are denominated in local currency, collected using the Bloomberg Professional Terminal and calculated by Citigroup. For Switzerland, we collect short-term (3–5-year) and long-term (7–10-year) bond series, whereas globally we only collect a long-term (7–10-year) bond series.

3.5 Modified Burke ratio

To calculate the Burke ratio, we subtract the risk-free rate from the portfolio return and divide it by the square root of the sum of the square of the drawdowns. We report the modified Burke ratio, which is the Burke ratio multiplied by the square root of the number of observations. We set the risk-free return equal to zero:

$$\text{modified Burke ratio} = \frac{(R_{\text{P}} - R_{\text{rf}})}{\sqrt{\sum_{t=1}^{d} (D_t^2/n)}}. \tag{3.5}$$

3.6 Calmar ratio

To calculate the Calmar ratio, we divide the annualized return by the absolute value of the maximum drawdown that the strategy experienced:

$$\text{Calmar ratio} = \frac{R_{\text{ann}}}{|\text{MDD}|}. \tag{3.6}$$

4 DATA

The data we use in our empirical analysis can be split into two subsets. The first contains the bond return series, for which we decide to use the country-specific Citigroup GBI bond series. For Switzerland, we store daily return observations for the 3–5-year and 7–10-year duration bonds, while for the global bond market we collect the 7–10-year Citigroup WGBI data (see Table 1). We store principal and total return data for all of these time series. While we calculate the bond market factors for Switzerland and for the world as a whole ourselves, the factors for the other countries are calculated by Morgan Stanley.

In Table 2, we provide an overview of all of the series used in our empirical analysis.[3]

[3] In the data section, we list all of the data used for the empirical tests in our main paper. The data used for robustness checks and other countries is reported in the online appendix.

TABLE 2 All input factors used to calculate the bond market factors (panel (a)) and data used for the drawdown analysis in Section 6 (panel (b)). [Table continues on next page.]

(a)

Factor/*Input data series*	**Region**	**First date**
Bond market factor Switzerland business cycle	Switzerland	April 30, 1999
KOF Economic Barometer		
Bond market factor Switzerland carry	Switzerland	April 30, 1999
Government bond 10-year yields		
Government bond 2-year yields		
Bond market factor Switzerland equities	Switzerland	April 30, 1999
Swiss Performance Index		
MSCI USA Index	*USA*	
MSCI Europe ex Switzerland Index	*Europe*	
MSCI Emerging Markets Index	*Emerging markets*	
Bond market factor Switzerland momentum	Switzerland	April 30, 1999
Citigroup GBI 3–5 year		
Citigroup GBI 7–10 year		
Bond market factor Switzerland overall	Switzerland	April 30, 1999
Bond market factor world business cycle	World	June 2, 1994
Bond market factor Australia business cycle	*Asia*	
Bond market factor Canada business cycle	*North America*	
Bond market factor Germany business cycle	*Europe*	
Bond market factor Japan business cycle	*Asia*	
Bond market factor UK business cycle	*Europe*	
Bond market factor US business cycle	*USA*	
Bond market factor world carry	World	June 2, 1994
Bond market factor Australia carry	*Asia*	
Bond market factor Canada carry	*North America*	
Bond market factor Germany carry	*Europe*	
Bond market factor Japan carry	*Asia*	
Bond market factor UK carry	*Europe*	
Bond market factor US carry	*USA*	
Bond market factor world equities	World	June 2, 1994
Bond market factor Australia equities	*Asia*	
Bond market factor Canada equities	*North America*	
Bond market factor Germany equities	*Europe*	
Bond market factor Japan equities	*Asia*	
Bond market factor UK equities	*Europe*	
Bond market factor US equities	*USA*	

TABLE 2 Continued.

(a)

Factor/*Input data series*	Region	First date
Bond market factor world momentum	World	June 2, 1994
Bond market factor Australia momentum	*Asia*	
Bond market factor Canada momentum	*North America*	
Bond market factor Germany momentum	*Europe*	
Bond market factor Japan momentum	*Asia*	
Bond market factor UK momentum	*Europe*	
Bond market factor US momentum	*USA*	
Bond market factor world overall	World	June 2, 1994
Bond market factor Australia overall	*Asia*	
Bond market factor Canada overall	*North America*	
Bond market factor Germany overall	*Europe*	
Bond market factor Japan overall	*Asia*	
Bond market factor UK overall	*Europe*	
Bond market factor US overall	*USA*	

(b)

Factor/*Input data series*	Region	First date
Swiss National Bank three-month Libor	Switzerland	April 30, 1999

The data in panel (a) was collected using the Bloomberg Professional Terminal, while the data in panel (b) was downloaded from the Swiss National Bank's data repository.

4.1 Switzerland

As a major contribution of this paper, we develop and construct four individual and two composite bond market factors for Switzerland. We are particularly interested in having a model that also covers Switzerland, as it is a major region in the investment industry and widely considered to be a safe haven in times of stressed financial markets. While the bond market momentum factor is based on the bond return series itself, we have to collect additional data for the carry, equity market performance and business cycle factors (all listed in Table 2). To calculate our carry factor, we use 10-year and 2-year Swiss government yield data. To construct the business cycle factor, we use the KOF Economic Barometer, which is published by the KOF Swiss Economic Institute. This is a leading composite indicator that predicts how the Swiss economy is expected to perform in the near future. To calculate the equity market performance factor, we use the Swiss Performance Index total return series. This contains the stocks of almost all of the companies that are domiciled in either Switzerland or Liechtenstein. To calculate the second equity market signal, the emerging markets versus developed markets performance differential, we use daily return data from the MSCI USA, MSCI Europe ex Switzerland and MSCI Emerging Markets indexes. The factor construction itself follows the methodology outlined in Sections 2.1–2.4. For our drawdown analysis in Section 6, we collect daily observations of the three-month London Interbank Offered Rate (Libor) data provided by the Swiss National Bank for the same period for which we have factor data.

4.2 World

To construct the four individual bond market factors for the global bond market, we calculate the equally weighted average across all of the available regional factors. The criterion for selecting the countries used to calculate the global factors is determined solely by the availability of factors in the financial database, as provided by Morgan Stanley. The four individual global factors are then manipulated, as described above in Section 2.5, to model the global composite bond market factors: collection and overall.

5 FACTOR INVESTMENT STRATEGIES

In this section, we explain how the factors described in Section 2 are translated into a tradeable bond market investment strategy that supports our efforts to obtain a view on bond market duration and guides us in our tactical interest rate market view. We divide our empirical analysis into two parts. We call the first strategy the "market-timing strategy", as we are either invested in bonds or move to cash (or vice versa). We call the second strategy the "duration-switching strategy", as this model tells us whether we should be invested in short-term or long-term bonds. The tested time period for all reported empirical backtests spans from April 30, 1999 to December 31, 2015.

5.1 Market-timing strategy

The market-timing strategy is either invested in bonds or holds cash. While our benchmark strategy always holds cash, we also report on the performance of the buy-and-hold strategy's investment in bonds of the same duration as the investments of the market-timing strategy. We do this because some of the performance metrics cannot reasonably be benchmarked to cash, as it does not generate returns and does not experience volatility or drawdowns.[4] Mathematically, we can formulate the

[4] Assuming cash to be a zero-return investment.

TABLE 3 Performance metrics for Switzerland based on long-term bonds.

	BH	CYC	CRY	EQY	MOM	COL	OVL
Ann. return	0.0241	0.0179	0.0147	0.0175	0.0207	0.0208	0.0215
Ann. SD	0.0297	0.0215	0.0191	0.0224	0.0222	0.0215	0.0216
Ann. Sharpe	0.8107	0.8320 ***	0.7657	0.7844	0.9293 ***	0.9677 ***	0.9932 ***
Max. drawdown	0.0924	0.0458 ***	0.0462 ***	0.0600 ***	0.0484 ***	0.0426 ***	0.0426 ***
Avg. drawdown	0.0076	0.0065	0.0059	0.0072	0.0064	0.0058	0.0059
Avg. length	36.8671	49.8482	53.9091	57.6569	51.4590	47.3939	46.6269
Avg. recovery	17.1456	29.9643	27.1364	38.3235	32.5246	31.9697	31.5299
Sortino	0.0754	0.0800 ***	0.0723	0.0746	0.0897 ***	0.0936 ***	0.0961 ***
B&L	1.1879	1.3124 ***	1.2608 ***	1.2784 ***	1.3018 ***	1.3486 ***	1.3533 ***
Mod. Burke	13.6487	14.3884 ***	13.3720	13.5046	16.5102 ***	16.9097 ***	17.3909 ***
Calmar	0.2606	0.3909 **	0.3170	0.2925	0.4270 ***	0.4875 ***	0.5035 ***

B&L stands for Bernardo and Ledoit, and SD stands for standard deviation. Performance metrics for Switzerland, where BH = buy-and-hold, CYC = cycle, CRY = carry, EQY = equities, MOM = momentum, COL = collection and OVL = overall. The corresponding significance signs are as follows (applying the approach presented in Ledoit and Wolf (2008)): •significance at $p < 0.1$; *significance at $p < 0.05$; **significance at $p < 0.005$; and ***significance at $p < 0.001$.

active trading decision as follows:

$$\text{market timing} = \begin{cases} \text{invested in bonds if factor} > x, \\ \text{holds cash if factor} \leqslant x. \end{cases} \tag{5.1}$$

The strategy in this section is tested in a long-only environment.

Region: Switzerland, 7–10 years

As the market-timing strategy is either holding cash or invested in bonds, and because the reported benchmark is always invested in bonds, we expect our factor strategies to have higher Sharpe ratios as a result of lower volatility overcompensating for lower return figures. As shown in Table 3, our composite bond market factors generate a higher Sharpe ratio, as expected, due to lower volatility, despite generating lower returns. Truncating the signal around ± 1.5 also improves the annualized return; however, it remains lower than the return delivered by following a passive buy-and-hold strategy. The collection as well as the overall strategy reduce the maximum drawdown by more than 50%. Exiting the bond market, however, also implies longer

TABLE 4 Performance metrics for Switzerland based on short-term bonds.

	BH	**CYC**	**CRY**	**EQY**	**MOM**	**COL**	**OVL**
Ann. return	0.0162	0.0125	0.0099	0.0113	0.0123	0.0132	0.0134
Ann. SD	0.0149	0.0115	0.0100	0.0117	0.0118	0.0115	0.0115
Ann. Sharpe	1.0837	1.0893	0.9907	0.9585	1.0444	1.1476***	1.1615***
Max. drawdown	0.0441	0.0367***	0.0198***	0.0308***	0.0363***	0.0255***	0.0255***
Avg. drawdown	0.0037	0.0033	0.0030	0.0035	0.0033	0.0028	0.0029
Avg. length	35.7471	48.1121	50.1488	61.4896	51.7899	46.4697	47.1692
Avg. recovery	17.7471	23.4310	26.5372	39.5729	22.0840	28.1364	28.6923
Sortino	0.1023	0.1070***	0.0968	0.0919	0.1020	0.1131***	0.1144***
B&L	1.2653	1.4484***	1.3461***	1.3744***	1.3513***	1.4363***	1.4347***
Mod. Burke	19.2436	19.9620**	18.3188	17.3854	19.3057***	21.1295***	21.4040***
Calmar	0.3670	0.3405	0.4992*	0.3653	0.3382	0.5161***	0.5261***

B&L stands for Bernardo and Ledoit, and SD stands for standard deviation. Performance metrics for Switzerland, where BH = buy-and-hold, CYC = cycle, CRY = carry, EQY = equities, MOM = momentum, COL = collection and OVL = overall. The corresponding significance signs are as follows (applying the approach presented in Ledoit and Wolf (2008)): •significance at $p < 0.1$; *significance at $p < 0.05$; **significance at $p < 0.005$; and ***significance at $p < 0.001$.

average drawdowns and longer recovery periods. Every individual factor experiences a lower volatility than the benchmark strategy does, along with a reduced annual return. Maximum drawdown is also significantly reduced by each individual factor. As for the overall bond market factor strategy, every individual signal reduces the maximum drawdown approximately by half, again at the expense of a higher average drawdown length and longer recovery period. These observations translate into higher Bernardo and Ledoit, modified Burke, and Calmar ratios. From an individual factor perspective, bond market momentum performs best: it has the overall highest Sharpe ratio as a result of having the highest individual annualized return, and experiences the second-highest volatility. These strong factor properties are also reflected in the other performance metrics, namely, the Calmar, Sortino and modified Burke ratios.

Region: Switzerland, 3–5 years

In the short-term case (reported in Table 4), both composite strategies outperform the benchmark strategy in terms of the Sharpe ratio, as the lower volatility can compensate for the reduced annualized return. In addition, experienced worst and average drawdowns are lower than those of the benchmark strategy. As the Sortino, Bernardo and Ledoit, and modified Burke ratios are all better than those of the benchmark strategy, the results for our composite strategies are highly promising. Truncating the signal at ± 1.5 yields an improvement in the Sharpe ratio by raising the annualized return while keeping the volatility constant. The overall strategy is still able to keep the worst and average drawdowns below those experienced by the passive strategy. As for the collection factor, the Sortino, Bernardo and Ledoit, and modified Burke ratios are all better than in the benchmark case. Similar to the long-term bonds, the bond market momentum factor still performs strongly, while the cycle factor stands out as an outperforming contributor, yielding the highest annualized return and thereby generating the highest individual Sharpe ratio. The equity market performance factor attracts our attention as the worst performer, with an annualized return too low and volatility figures too high to beat the benchmark strategy on the Sharpe ratio level. However, every individual factor reduces the worst and average drawdowns relative to the benchmark strategy.

Region: world, 7–10 years

While the global collection bond market strategy fails to outperform the buy-and-hold strategy in most reported performance metrics, truncating unconvincing signals at ± 1.5 improves the overall composite factor, beating the buy-and-hold strategy on every reported metric apart from the average drawdown length. In addition, truncation reduces the average and worst drawdowns. For the first time, the average recovery period is smaller when applying our overall composite factor than when following the buy-and-hold approach. From an individual factor perspective, bond market momentum is by far the best-performing component. Generating the highest annualized return with a reasonable volatility, we report the highest Sharpe ratio for bond market momentum across the factors. While it performs comparably with the other factors when looking at the maximum drawdown, it performs best in terms of average drawdown. Across the ratios reported at the bottom of Table 5, bond market momentum achieves the best results. Equity market performance, however, is the worst-performing individual factor. Even though the equity strategy experiences the lowest volatility, this comes at the expense of the lowest annualized return; it also diminishes the strategy's Sharpe ratio. This result is in line with the other performance metrics, for which the equity market performance factor shows the worst results.

TABLE 5 Performance metrics for the world based on long-term bonds.

	BH	CYC	CRY	EQY	MOM	COL	OVL
Ann. return	0.0297	0.0224	0.0257	0.0149	0.0380	0.0208	0.0359
Ann. SD	0.0650	0.0459	0.0519	0.0448	0.0523	0.0521	0.0535
Ann. Sharpe	0.4573	0.4870 •	0.4952 •	0.3329	0.7269 ***	0.3989	0.6713 ***
Max. drawdown	0.1227	0.1336	0.1252	0.1047 ***	0.1056 ***	0.1236	0.1121 ***
Avg. drawdown	0.0201	0.0189	0.0179	0.0173	0.0139	0.0179	0.0157
Avg. length	62.7195	95.2364	80.7841	118.0351	54.9603	81.2188	56.6835
Avg. recovery	32.3171	64.6364	39.1818	73.4035	30.7483	34.0000	28.4820
Sortino	0.0443	0.0468 •	0.0475	0.0324	0.0714 ***	0.0387	0.0653 ***
B&L	1.1028	1.1582 ***	1.1449 ***	1.1100	1.2009 ***	1.1149 ***	1.1877 ***
Mod. Burke	8.1390	8.9110 *	8.9063	6.1147	13.9224 ***	7.2680	12.7257 ***
Calmar	0.2422	0.1674	0.2051	0.1424	0.3602 ***	0.1682	0.3204 ***

B&L stands for Bernardo and Ledoit, and SD stands for standard deviation. Performance metrics for the world, where BH = buy-and-hold, CYC = cycle, CRY = carry, EQY = equities, MOM = momentum, COL = collection and OVL = overall. The corresponding significance signs are as follows (applying the approach presented in Ledoit and Wolf (2008)): •significance at $p < 0.1$; *significance at $p < 0.05$; **significance at $p < 0.005$; and ***significance at $p < 0.001$.

5.2 Duration-switching strategy

The duration-switching strategy is invested in either short-term or long-term bonds. If the bond market factor indicates a good environment for bond investments, we invest in long-term bonds. If the factor signals worsening circumstances, however, we invest in short-duration bonds to reduce bond market risk. In terms of risk taking, the duration-switching strategy is a more aggressive model than the market-timing strategy of Section 5.1, as it never leaves the bond market entirely and remains invested, thereby remaining exposed to interest rate risk. Mathematically, we can formulate the active trading decision as follows:

$$\text{duration switching} = \begin{cases} \text{invested in long-term bonds if factor} > x, \\ \text{invested in short-term bonds if factor} \leqslant x. \end{cases} \tag{5.2}$$

The strategy in this section is tested in a long-only environment. The benchmark strategy is always invested in long-term bonds. Again, the official benchmark is cash, but we report the performance achieved by a buy-and-hold investment strategy (cf. with the reasoning in Section 5.1).

TABLE 6 Performance metrics for Switzerland.

	BH	CYC	CRY	EQY	MOM	COL	OVL
Ann. return	0.0241	0.0216	0.0210	0.0225	0.0246	0.0237	0.0244
Ann. SD	0.0297	0.0235	0.0221	0.0242	0.0241	0.0234	0.0235
Ann. Sharpe	0.8107	0.9174 ***	0.9486 ***	0.9289 ***	1.0221 ***	1.0110 ***	1.0347 ***
Max. drawdown	0.0924	0.0458 ***	0.0774 ***	0.0659 ***	0.0550 ***	0.0550 ***	0.0550 ***
Avg. drawdown	0.0076	0.0061	0.0060	0.0057	0.0064	0.0060	0.0061
Avg. length	36.8671	41.0000	39.2452	35.9706	40.8750	38.9497	39.4713
Avg. recovery	17.1456	24.2434	23.0774	19.2941	22.9803	22.0189	22.0955
Sortino	0.0754	0.0871 ***	0.0888 ***	0.0877 ***	0.0974 ***	0.0964 ***	0.0987 ***
B&L	1.1879	1.2389 ***	1.2366 ***	1.2392 ***	1.2599 ***	1.2662 ***	1.2703 ***
Mod. Burke	13.6487	15.8197 ***	16.4851 ***	15.9822 ***	17.9782 ***	17.5593 ***	17.9998 ***
Calmar	0.2606	0.4712 ***	0.2713 ***	0.3406 ***	0.4469 ***	0.4303 ***	0.4427 ***

B&L stands for Bernardo and Ledoit, and SD stands for standard deviation. Performance metrics for Switzerland, where BH = buy-and-hold, CYC = cycle, CRY = carry, EQY = equities, MOM = momentum, COL = collection and OVL = overall. The corresponding significance signs are as follows (applying the approach presented in Ledoit and Wolf (2008)): •significance at $p < 0.1$; *significance at $p < 0.05$; **significance at $p < 0.005$; and ***significance at $p < 0.001$.

Region: Switzerland

As we no longer move to cash once the factor signal shows us a worsening of the bond market environment, but rather move from long duration to short duration, we do not leave as much return potential on the table. This fact is clearly visible in terms of annualized returns (compare the reported returns in Table 6 with those in Tables 3 and 4). However, we are still exposed to interest rate risk. Yet, as the backtesting results for the collection factor strategy show, this pays off: even though the annualized return is lower than for the passive strategy, the lower volatility of our collection strategy overcompensates for this, which is reflected in a higher Sharpe ratio. Both the average and the worst drawdowns are improved by applying the active strategy; the latter is reduced by almost 50%. Satisfyingly, the other performance ratios also favor our collection strategy. Ignoring the volatility-related and drawdown-related figures, removing unconvincing signals at ± 1.5 significantly improves every single reported metric. Therefore, in summary, truncation pays off in the duration-switching model. Again, on average, bond market momentum turns out to be the best-performing individual factor. Apart from equity market performance, every other factor (individually or combined) has worse properties in terms of its average drawdown and recovery periods but outperforms the benchmark strategy in every other reported metric apart from annual return. While the other individual factors are also unable to beat the benchmark in terms of average recovery period, the equity factor successfully reduces average drawdown length, but insignificantly. Cycle, as a standalone component, performs surprisingly strongly in drawdown management, experiencing the lowest maximum drawdown. In summary, the duration-switcher for Switzerland performs strongly across all individual components, therefore supporting the decision to use all four factors as inputs to the overall strategy. As mentioned above, signal truncation is beneficial across every reported metric, supporting the case for removing unconvincing signals. However, we have to bear in mind that we have experienced years of declining interest rates, with only a few interest rate hikes.

6 DRAWDOWN BEHAVIOR

Changes in interest rate levels are the most important risk factor to consider when investing in sovereign bonds. We therefore analyze the largest drawdowns found in the Swiss long-term returns series. The inverse relationship of interest rates and bond prices implies that rising interest rates are reflected in lower bond prices, which, again, should be mirrored in our return data.[5] Therefore, we should detect overlapping periods of rising interest rates and experienced drawdowns in our principal return data.[6]

Looking at Figure 1, we can see that there were three periods of rising interest rates during our empirical backtesting window. At the beginning of the chart, in Spring 1999, is the starting point of the first interest rate increase: the rate rising to 3.57% by October 2000. The second interest rate increase began in January 2004, with the rate rising from 0.24% to reach 3.13% in October 2008. From June 2010 to May 2011, we detect another period of rising interest rates, although this time it is significantly lower in magnitude. We can thus build three consecutive periods of rising interest rates:

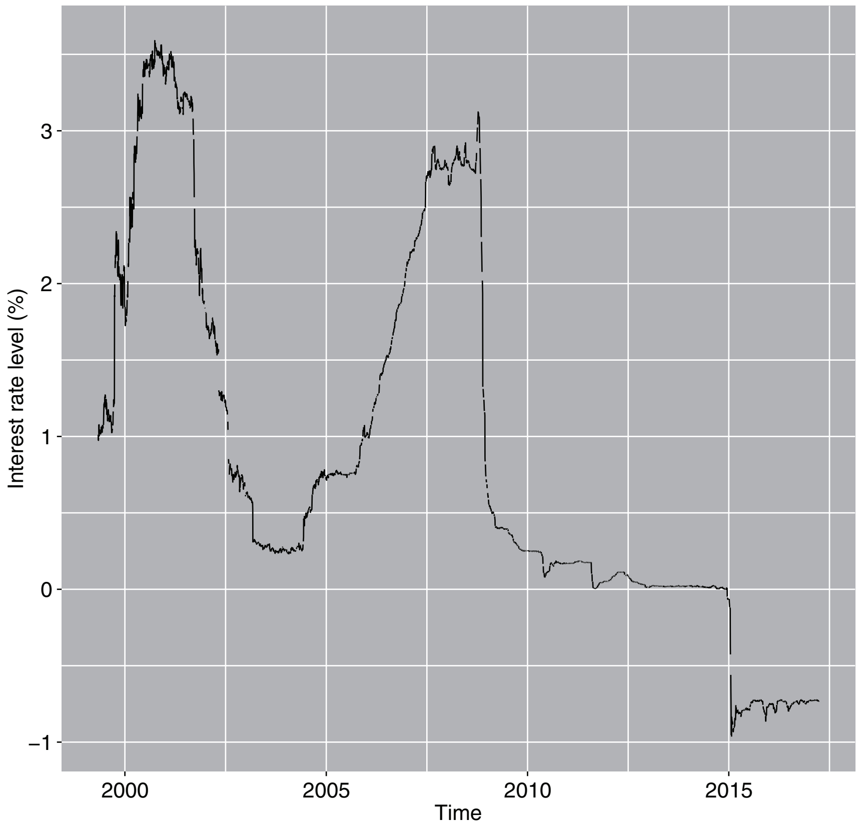
(1) April 1999–October 2000;

(2) January 2004–October 2008;

[5] This rationale is reaffirmed when we look at the interest data provided by central banks, taking the Swiss case as a representative example. See https://bit.ly/2kQSTON.

[6] The principal return is a daily index, calculated as the previous day's index value adjusted by the percentage change in the underlying securities' clean price; formally $\mathrm{PR}_{I,t} = \mathrm{PR}_{I,t-1} \times (\sum_{I=1}^{n} \mathrm{WCP}_{I,t} / \sum_{I=1}^{n} \mathrm{WCP}_{I,t-1})$, where WCP is the weighted average clean price of all the securities in the index, and PR is the principal return index on that day.

FIGURE 1 Plot of the Swiss three-month Libor rate.



This chart is used as an indicator for interest rate levels in Switzerland. It spans from April 29, 1999 to December 31, 2015.

(3) June 2010–May 2011.

To assess the quality of our factor strategies, we first extract the largest drawdowns found in our principal return series as a proxy for interest rate increases, and then extract the largest drawdowns experienced when following our factor-based investment strategy. While we use principal return data to reaffirm that changes in interest rate levels are reflected in our price series, we use total return data to compare the performance of our factor investment strategies relative to the buy-and-hold strategy.

TABLE 7 The largest drawdowns detected in the long-term principal return data for Switzerland.

	From	Trough	To	Depth	Length	To trough	Recovery
1	1999-05-31	2000-06-29	2003-01-11	−0.9825	1322	396	926
2	2005-06-30	2008-07-30	2010-05-17	−0.9701	1783	1127	656
3	2010-09-30	2011-05-30	2011-09-21	−0.8317	357	243	114
4	2012-08-31	2014-01-30	2015-02-22	−0.8268	906	518	388
5	2003-03-31	2004-07-30	2005-05-07	−0.7999	769	488	281
6	2015-12-31	2016-01-30	2016-04-17	−0.5343	109	31	78
7	2015-02-28	2015-07-30	2015-12-19	−0.4106	295	153	142
8	2012-06-30	2012-07-30	2012-08-28	−0.3016	60	31	29
9	2012-02-29	2012-04-29	2012-06-08	−0.2814	101	61	40
10	2011-10-31	2011-11-29	2011-12-28	−0.1657	59	30	29

Principal return

Table 7 reports the drawdowns detected in the long-duration principal return bond data for Switzerland. Strikingly, we observe that six out of ten of the largest drawdowns in Table 7 were larger than 50%, with the biggest occurring from May 1999 to January 2003, with a depth of 98.25%. Obviously, these are not the drawdowns we would expect from a reasonable passive sovereign bond investment, but we have to keep in mind that these figures are from principal return data and not total return data, which we will discuss later. In the list that follows, we present the periods in which the highest drawdowns in principal returns are detected:

(1) May 1999–January 2003;

(2) June 2005–May 2010;

(3) September 2010–September 2011.

Comparing these periods with our findings based on the interest rate data provided by the Swiss National Bank, we discover that the periods of rising interest rates and the largest drawdowns in principal return data do indeed overlap. This affirms the inverse relationship between interest rates and bond prices. While the drawdown periods are longer than the periods of rising interest rates, the peaks in interest rate levels and the drawdown troughs are observed around the same dates. This supports our thesis, and we therefore move on to our total return analysis.

TABLE 8 The largest drawdowns detected in the long-term total return data for Switzerland.

	From	Trough	To	Depth	Length	To trough	Recovery
1	1999-04-30	2000-05-19	2001-03-22	–0.0924	693	386	307
2	2005-09-23	2007-07-09	2008-01-23	–0.0662	853	655	198
3	2010-08-25	2011-04-11	2011-07-27	–0.0543	337	230	107
4	2003-06-12	2003-09-03	2004-03-08	–0.0515	271	84	187
5	2001-11-08	2002-03-08	2002-06-26	–0.0458	231	121	110
6	2012-12-11	2013-09-10	2014-05-08	–0.0453	514	274	240
7	2008-03-25	2008-06-19	2008-08-13	–0.0441	142	87	55
8	2003-03-12	2003-04-07	2003-06-10	–0.0410	91	27	64
9	2004-03-16	2004-06-29	2004-10-11	–0.0376	210	106	104
10	2015-01-26	2015-06-10	2015-11-10	–0.0342	289	136	153

Buy-and-hold

First, we observe in Table 8 that the drawdown depth is significantly lower than the results reported in the previous part based on principal return data (see Table 7) and relative to the expected range for bond investments.

We observe three major drawdown periods for the total return long-term bond data, namely:

(1) April 1999–March 2001;

(2) September 2005–January 2008;

(3) August 2010–July 2011.

These periods overlap with the increases in interest rates, as depicted in Figure 1. The worst drawdown detected in the long-term total return series is 9.24%; this is followed by a drawdown of 6.62% and three smaller drawdowns of around 5%. Again, the drawdown periods are longer than the periods of rising interest rates, as the bonds need time to recover the losses. We will set this information to one side, to refer back to during our relative evaluation of the performance of our factor strategies, and move on to an analysis of the drawdowns experienced when using bond market factors.

Factor: overall

As the overall strategy is our final product and should be used as the guiding tool in the asset allocation process, we start our drawdown analysis with it.[7] Our first

[7] We do not report the drawdown analysis of the collection bond market factor, as the results are similar.

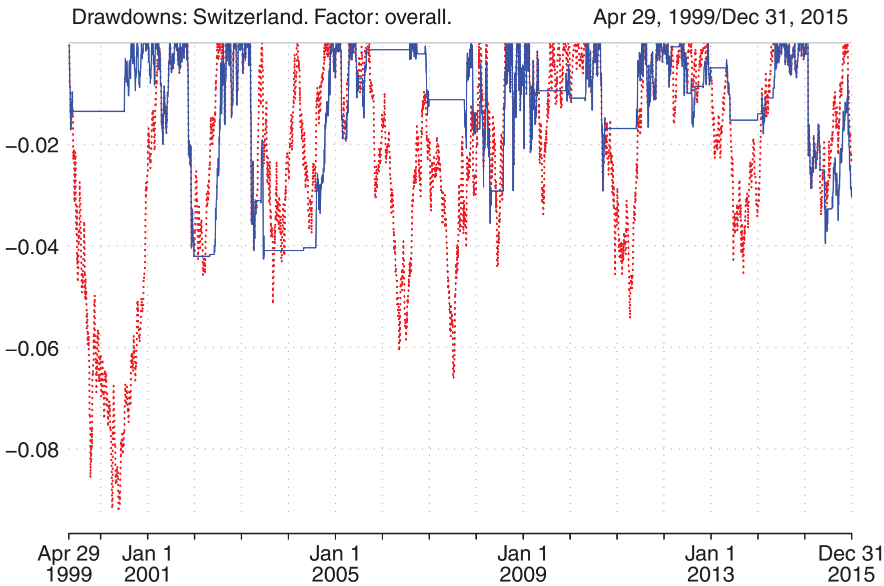
TABLE 9 The largest drawdowns experienced when following the active factor strategy overall, based on total return data for Switzerland.

	From	Trough	To	Depth	Length	To trough	Recovery
1	2003-03-12	2003-06-23	2004-12-03	−0.0426	633	104	529
2	2001-11-08	2001-12-28	2002-08-14	−0.0421	280	51	229
3	2015-01-26	2015-06-10	—	−0.0395	796	136	—
4	2007-11-26	2008-04-18	2008-08-20	−0.0356	269	145	124
5	2010-08-25	2010-09-13	2011-07-11	−0.0292	321	20	301
6	2008-10-09	2008-10-14	2008-11-11	−0.0291	34	6	28
7	2009-02-19	2009-02-26	2010-05-06	−0.0217	442	8	434
8	2008-12-08	2009-01-07	2009-01-14	−0.0209	38	31	7
9	2006-09-27	2007-10-16	2007-11-19	−0.0208	419	385	34
10	2001-03-28	2001-04-30	2001-06-26	−0.0201	91	34	57

observation is that even the largest drawdown, which occurred between March 2003 and December 2004, was smaller than 5% and therefore significantly lower than the worst drawdown experienced by passively holding on to the asset as well as lower than the five worst drawdowns listed in Table 8 for the buy-and-hold strategy. Our second observation is that the time periods in which the ten largest drawdowns are experienced when following our overall bond market factor only overlap with two interest rate hike periods: namely, January 2004 to October 2008 and June 2010 to May 2011. However, five out of ten reported drawdowns occur during these periods. Our third observation is that none of the three worst drawdown periods in the benchmark strategy are visible in the overall strategy's drawdown table; therefore, it seems that applying the overall factor successfully circumvents the periods in which the largest drawdowns are experienced in the underlying asset, and no significant losses occur during these periods.

Looking at the worst drawdown of 4.26%, we can identify that this drawdown occurred during a period in which the passive strategy also experienced drawdowns, including its fourth largest of 5.15%. While the drawdown length of the overall strategy is significantly longer than that of the buy-and-hold strategy, the factor strategy is able to reduce the drawdown depth by almost 1%, or 17% in relative terms. The second largest drawdown reported in Table 9 is 4.21%. We find that the same period in Table 8, showing the drawdowns of the buy-and-hold strategy, has a magnitude of 4.58%. While this reduction of 0.37% in absolute and 8% in relative terms seems negligible, it is actually remarkable: this is the second-largest drawdown experienced following the overall factor and the fifth-largest drawdown reported in Table 8. Comparing the fourth-largest drawdown – 3.56% in Table 9 – with the drawdown experi-

FIGURE 2 Plot of the drawdown function for the overall factor.



Plot of the drawdown function for the overall factor (blue) and the buy-and-hold strategy (red, dotted), both based on the long-term bond series.

enced during the same period for the buy-and-hold strategy at a magnitude of 4.41% again supports the strength of our overall bond market factor, reducing the drawdown by 0.8% in absolute and by 19% in relative terms. These findings support our aforementioned reasoning on the superior drawdown behavior of the overall bond market factor strategy. Figure 2 provides a graphical representation of the drawdown functions. To deepen the analysis, we now move on to the largest drawdowns experienced following the individual factors: cycle, carry, equity market performance and bond market momentum.

Factor: cycle

The three largest drawdown periods resulting from the cycle factor strategy reported in Table 10 and Figure 3 overlap with the fifth-, seventh- and eighth-largest drawdowns in the underlying bond return series, respectively. While the length of the largest drawdown is fifty days longer than that of the underlying asset, the other two drawdowns display the same drawdown length as the asset. Disappointingly, all of these drawdowns are of exactly the same magnitude as those of the buy-and-hold strategy and therefore do not add any protection in terms of drawdown management

TABLE 10 The largest drawdowns experienced when following the active factor strategy cycle, based on total return data for Switzerland.

	From	Trough	To	Depth	Length	To trough	Recovery
1	2001-11-08	2002-03-08	2002-08-14	–0.0458	280	121	159
2	2008-03-25	2008-06-19	2008-08-13	–0.0441	142	87	55
3	2015-01-26	2015-06-10	—	–0.0431	796	136	—
4	2003-03-12	2003-04-07	2003-06-10	–0.0410	91	27	64
5	2009-02-19	2009-05-28	2011-06-10	–0.0317	842	99	743
6	2008-10-09	2008-10-14	2008-11-11	–0.0291	34	6	28
7	2008-02-06	2008-02-27	2008-03-21	–0.0244	45	22	23
8	2003-06-12	2003-06-23	2004-11-23	–0.0240	531	12	519
9	2008-12-08	2009-01-07	2009-01-14	–0.0209	38	31	7
10	2001-03-28	2001-04-30	2001-06-26	–0.0201	91	34	57

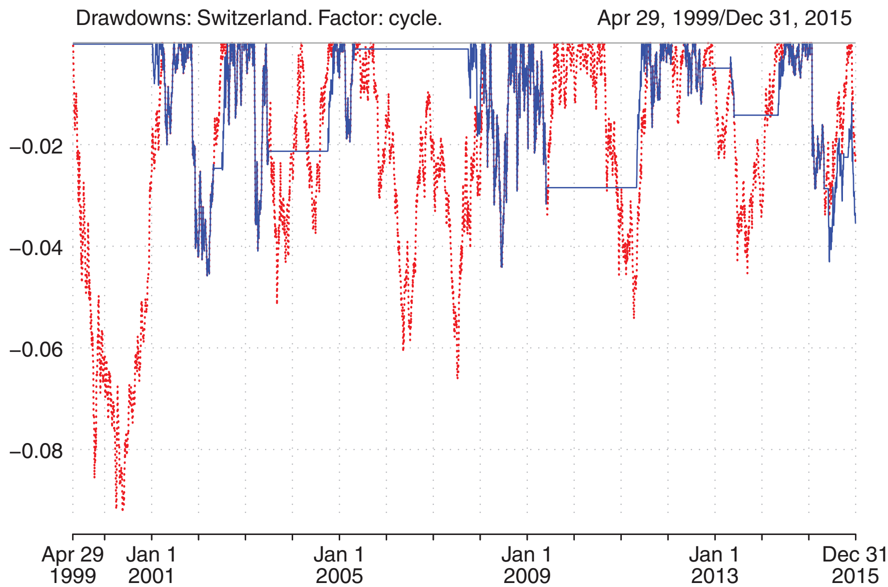
in these cases. However, the biggest drawdowns reported in the cycle strategy are significantly – up to 50% – lower than those experienced as a buy-and-hold investor. To illustrate this, consider the fact that the largest drawdown resulting from the cycle factor is only the fifth largest that a buy-and-hold investor experiences. In addition, Table 8 reports the fourth-largest drawdown in the period June 12, 2003–March 8, 2004 (5.15%), while the cycle factor is only hit by a 4.1% drawdown in March 12, 2003–June 10, 2003 and therefore successfully reduces this drawdown.

Factor: carry

Six out of ten drawdowns reported for our carry strategy occur during the three periods of rising interest rates. Our first observation upon looking at Table 11 and Figure 4 is that the largest drawdown experienced when following the carry strategy is smaller than the four largest observed in the underlying asset. With a magnitude of 4.62%, the largest drawdown reported for the carry factor occurs during the second major prolonged period of rising interest rates. During this same period, the buy-and-hold investor lost 6.62%: 2% more in absolute terms and more than 30% more in relative terms.

In addition, the period in which the second-largest drawdown for the carry strategy occurs overlaps with a drawdown period reported for the buy-and-hold strategy, as shown in Table 8. This results in its largest loss of 9.24%. In contrast, the carry factor strategy loses only 4.14%: a reduction of 5% on an absolute basis or 55% in relative terms. Moving down the list to the third-largest drawdown reported in Table 11, we recognize a loss of 3.64% during the period June 2003–November 2004. The underlying asset, however, loses significantly more, with a reported drawdown of

FIGURE 3 Plot of the drawdown function for the factor cycle.



Plot of the drawdown function for the factor cycle (blue) and the buy-and-hold strategy (red, dotted), both based on the long-term bond series.

5.15%. Again, this is a reduction of more than 1.5% in absolute terms and almost 30% on a relative basis.

Factor: equity market performance

The equity market performance factor is the only factor that experiences a drawdown larger than 5%, with one of 6%. The aforementioned drawdown occurs between July 1999 and January 2001 (see Table 12 and Figure 5), which is also when the largest drawdown of the underlying is observed. The latter, however, has a magnitude of 9.24% and is therefore 3.24% – or, in relative terms, 35% – larger. The equity market performance factor clearly reduces this by entering the drawdown period three months later. This drawdown period overlaps with the first reported period of rising interest rates. The longest period of interest rate hikes ran from January 2004 to October 2010. Clearly, the second-, third-, seventh- and ninth-largest drawdowns occurred during this period. We also report the second-largest drawdown for the underlying total return series in this period: 6.62%. While the equity market performance factor experiences the second-largest drawdown with a performance impact of 4.52%, its duration – over 1200 days – is remarkably long. The third-largest drawdown reported

TABLE 11 The largest drawdowns experienced when following the active factor strategy carry, based on total return data for Switzerland.

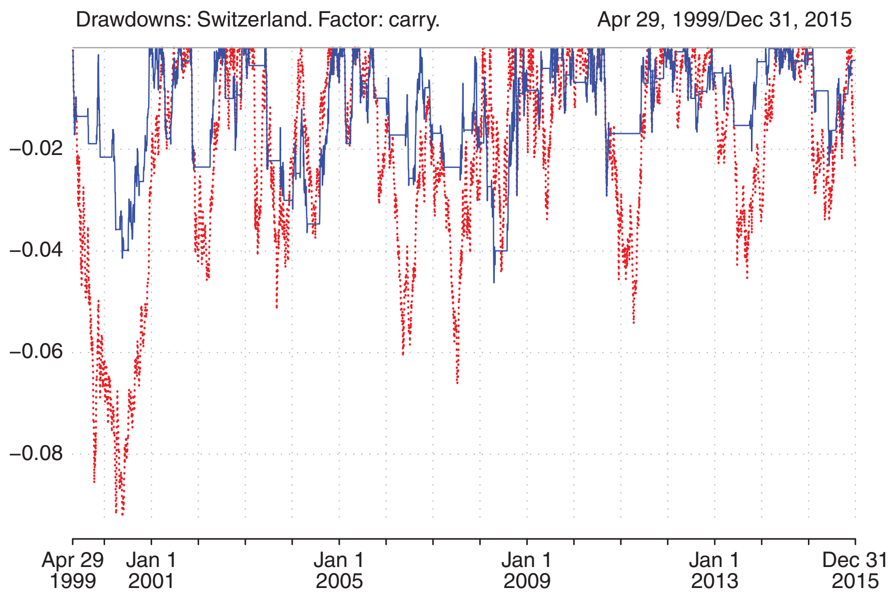
	From	Trough	To	Depth	Length	To trough	Recovery
1	2006-09-27	2008-04-18	2008-09-29	−0.0462	734	570	164
2	1999-04-30	2000-05-19	2000-12-15	−0.0414	596	386	210
3	2003-06-12	2004-04-26	2004-11-11	−0.0364	519	320	199
4	2010-08-25	2010-09-13	2011-08-05	−0.0292	346	20	326
5	2008-10-09	2008-10-14	2008-12-03	−0.0291	56	6	50
6	2005-09-23	2006-06-26	2006-09-25	−0.0271	368	277	91
7	2001-11-08	2001-11-27	2002-06-10	−0.0241	215	20	195
8	2015-02-03	2015-06-10	2016-02-18	−0.0232	381	128	253
9	2012-12-11	2013-10-16	2014-01-31	−0.0203	417	310	107
10	2002-07-25	2002-10-15	2002-12-06	−0.0202	135	83	52

during the period March 2008–August 2008 generates a loss of 4.34%, which is slightly less than the drawdown experienced by the buy-and-hold investor during the same period, with an impact of 4.41%. However, it is again important to keep in mind that, while this drawdown of 4.34% is only slightly smaller than that experienced as a buy-and-hold investor, it is the third-largest result from employing the factor strategy. For the buy-and-hold investment strategy, meanwhile, it is only the seventh-largest reported loss.

Factor: bond market momentum

Following the bond market momentum factor strategy implies a maximum drawdown of 4.84% (see Figure 6) during the period June 2012–November 2011. The detected drawdown is therefore larger than that reported using the buy-and-hold strategy over a similar time period (namely, from December 2012 to May 2014). The bond market momentum factor, which adjusts its signals slowly, amplifies the drawdown as it starts losing money earlier and does so for a longer time period. The same is true of the second-largest drawdown reported in Table 13, where the bond market momentum signal is again lagging and therefore losing money for too long. Interestingly, only the fifth-, sixth-, seventh- and tenth-largest drawdowns occur during the three sustained periods of rising interest rates. Bond market momentum, therefore, is able to reduce the worst drawdowns experienced by the buy-and-hold investor, but it fails to completely convince in certain periods of rising interest rates.

FIGURE 4 Plot of the drawdown function for the factor carry.



Plot of the drawdown function for the factor carry (blue) and the buy-and-hold strategy (red, dotted), both based on the long-term bond series.

7 ADDITIONAL RESULTS

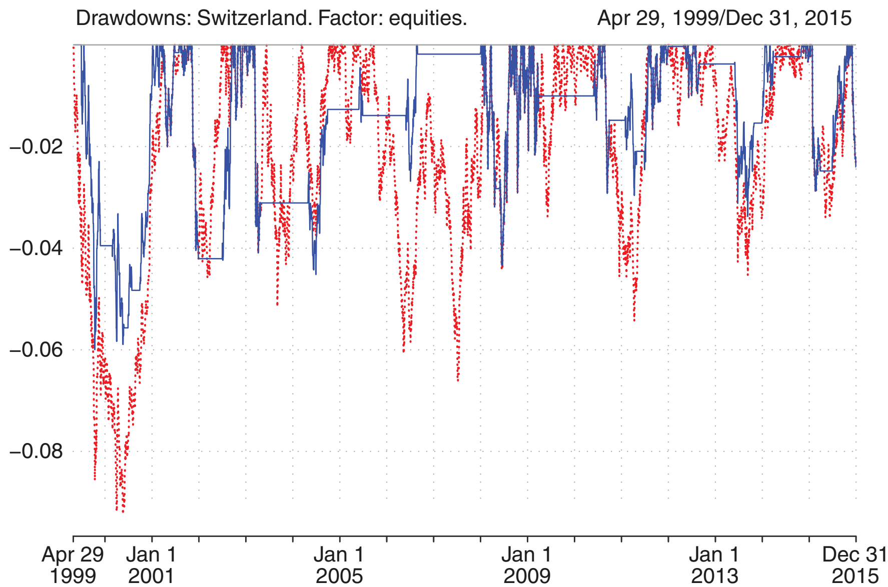
While we report the results for both the Swiss and the global sovereign bond markets in the main paper, we provide the empirical results of our market-timing and duration-switching strategies for Australia, Canada, Germany, Japan, the United Kingdom and the United States in an online appendix. Similar to our main results, the market-timing strategy shows superior results in terms of Sharpe ratios based on the overall factor for most of these countries. While Japan and Germany show the most promising results, we find the worst results for Australia and Canada. From an individual factor perspective, momentum appears to be the best-performing factor, generating the highest Sharpe ratio across all tested countries for both long-duration and short-duration bonds. The worst performing individual factors for the long-duration market-timing strategies are carry and equity market performance. On the short-duration side, we find the cycle factor to be one of the worst-performing indicators. Similar to the main results, the experienced maximum drawdown can also be significantly reduced relative to the buy-and-hold strategy by following our overall factor signal. For the duration-switching strategy, we obtain results for Germany,

TABLE 12 The largest drawdowns experienced when following the active factor strategy equity market performance, based on total return data for Switzerland.

	From	Trough	To	Depth	Length	To trough	Recovery
1	1999-07-23	1999-10-14	2001-01-05	–0.0600	533	84	449
2	2003-03-12	2004-06-29	2006-08-22	–0.0452	1260	476	784
3	2008-03-25	2008-06-19	2008-08-13	–0.0434	142	87	55
4	2001-11-08	2002-07-05	2002-09-16	–0.0424	313	240	73
5	2012-08-03	2013-09-10	2014-01-21	–0.0338	537	404	133
6	2010-08-25	2011-04-11	2011-07-29	–0.0296	339	230	109
7	2008-10-09	2008-10-14	2008-11-11	–0.0291	34	6	28
8	2015-01-26	2015-02-18	2015-10-21	–0.0287	269	24	245
9	2008-02-06	2008-02-27	2008-03-21	–0.0244	45	22	23
10	2015-12-02	2015-12-30	2016-02-29	–0.0240	90	29	61

the United Kingdom, the United States, Japan and Canada that support our main findings; namely, higher Sharpe ratios generated by the overall factor relative to the buy-and-hold strategy. However, we report a lower Sharpe ratio for Australia when following the overall factor. Momentum appears to be the best individual factor, generating the highest Sharpe ratio in four out of six backtests, with carry being the best-performing individual factor in the remaining two backtests. Also in line with our main results are the findings from our analysis of drawdowns: investing according to the overall factor yields a significant reduction in experienced drawdowns. The overall factor not only reduces the maximum drawdown but also, on average, reports a lower maximum drawdown than the three-to-five-largest drawdowns observed in the underlying asset. The overall factor, which shows the worst results for Australia and Canada, reduces the maximum drawdown by 56% and 64%, respectively. On top of this, the maximum drawdown resulting from the overall factor for Australia is smaller than the four largest detected drawdowns in the underlying asset, and in the Canadian case it has the same magnitude as the sixth-largest drawdown reported for the buy-and-hold strategy. The overall factor for Japan – the outstanding performer of our abovementioned backtests – experiences a maximum drawdown of 2.77%, while the buy-and-hold investor suffers a maximum drawdown of more than 10%. The experienced loss of 2.77% is less than the eleventh-largest drawdown experienced by the buy-and-hold investor.

FIGURE 5 Plot of the drawdown function for the factor equity market performance.



Plot of the drawdown function for the factor equity market performance (blue) and the buy-and-hold strategy (red, dotted), both based on the long-term bond series.

8 CONCLUSION

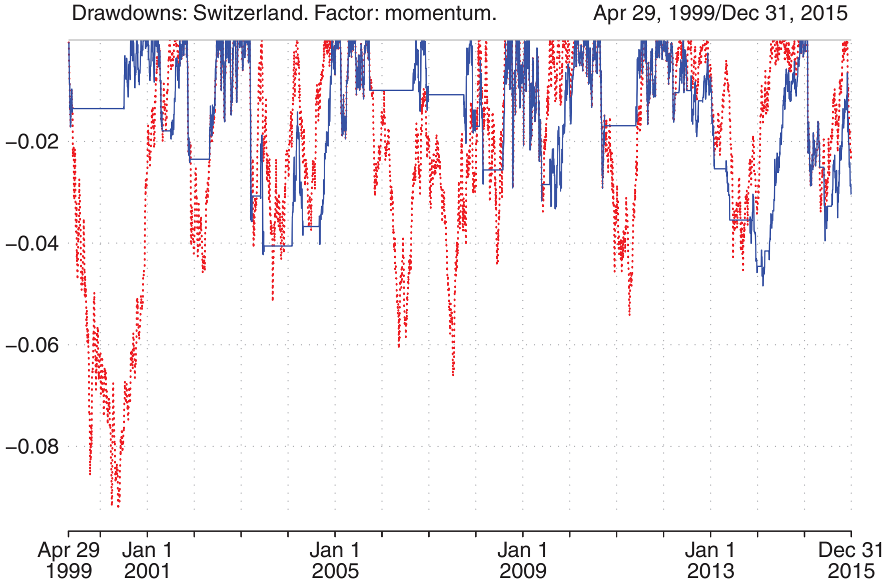
In this paper, we develop a bond market factor for Swiss sovereign bonds to guide the duration discussion in asset allocation committees as well as to support the asset allocation decision between bonds and cash. We construct Swiss and global bond market factors that extend Morgan Stanley's universe of bond market factors. Using four region-specific individual factors, we build an equally weighted overall factor to signal whether investments in particular sovereign bond markets are attractive or whether we should lower our risk by either moving into cash or reducing the duration. In our empirical analysis, we show that our sovereign bond market factor is able to beat holding cash as well as the static buy-and-hold strategy by employing an active bond market investment strategy, thereby improving the Sharpe ratio, annualized standard deviation and maximum drawdown of each region. To do so, we test two active bond market strategies. We call the first the market-timing strategy, for which we invest in the same duration bonds as for the buy-and-hold strategy but exit trades once the respective bond market factor signals us to do so, and accordingly move to cash. We call the second the duration-switching strategy. In it,

TABLE 13 The largest drawdowns experienced when following the active factor strategy bond market momentum, based on total return data for Switzerland.

	From	Trough	To	Depth	Length	To trough	Recovery
1	2012-06-01	2014-02-12	2014-11-28	–0.0484	911	622	289
2	2003-03-12	2003-06-23	2004-12-08	–0.0423	638	104	534
3	2015-01-26	2015-06-10	—	–0.0395	796	136	—
4	2009-02-19	2009-09-10	2010-02-10	–0.0333	357	204	153
5	2010-08-25	2010-09-13	2011-07-11	–0.0292	321	20	301
6	2008-10-09	2008-10-14	2008-11-11	–0.0291	34	6	28
7	2007-11-26	2008-02-27	2008-09-05	–0.0284	285	94	191
8	2001-11-08	2001-11-27	2002-06-26	–0.0241	231	20	211
9	2008-12-08	2009-01-07	2009-01-14	–0.0209	38	31	7
10	2006-11-21	2007-10-16	2007-11-19	–0.0204	364	330	34

we are invested in long-duration bonds if the market for bonds is attractive, but we move to short-duration bonds if the environment for bonds worsens. In terms of risk taking, the duration-switching strategy is clearly more aggressive than the market-timing strategy, as the investor is still exposed to bond market risks even if circumstances worsen. The empirical results of our study are in line with this economic reasoning: the duration switcher is able to generate higher returns accompanied by higher experienced volatility. However, the higher returns compensate the increase in volatility, resulting in a higher Sharpe ratio compared with the market-timing strategy. While we also report better Sortino and modified Burke ratios for the duration-switching strategy, the market-timing strategy shows superior results in terms of both the Bernardo and Ledoit and the Calmar ratios. Even though the drawdown experienced in the duration-switching strategy is higher than that of the market-timing strategy, the relatively higher return generated by the duration-switching strategy overcompensates for this, resulting in a slightly higher Sortino ratio. As the modified Burke ratio is also connected to the drawdowns experienced, the same reasoning can be applied to explain the inferiority of the market-timing strategy. However, the Bernardo and Ledoit ratio, which captures the ratio of positive to negative returns, favors the market-timing strategy. As the market-timing strategy sells all bond holdings once the bond market factor indicates a bad environment for bond investments and moves entirely into cash, the denominator of this performance metric is smaller; this means it yields superior results relative to the duration-switching strategy, which is always exposed to bond market risks. The superior results for the market-timing strategy in terms of the Calmar ratio are a result of the lower maximum drawdown experienced by this strategy. Again, this does not come as a surprise, as the market-

FIGURE 6 Plot of the drawdown function for the factor bond market momentum.



Plot of the drawdown function for the factor bond momentum (blue) and the buy-and-hold strategy (red, dotted), both based on the long-term bond series.

timing strategy is allowed to leave the bond market completely, while the duration-switching strategy can only reduce bond market risk by lowering portfolio duration. However, we have to keep in mind that, over recent years, interest rates have been falling constantly, and therefore being invested in short-duration bonds has not paid off relative to taking more interest rate risk by being invested in long-duration bonds. This fact is also reflected in the lower Sharpe ratio achieved by the passive buy-and-hold strategy for short-term Swiss sovereign bonds compared with their longer-term counterparts. Generally, falling interest rates are also reported in our extended analysis on drawdown behavior, where we find that our overall strategy outperforms the buy-and-hold strategy in times of rising interest rates, therefore anticipating a negative impact on bond portfolios. All told, we find that not only the final bond market factor strategy but also the individual input factors outperform the buy-and-hold strategy in their drawdown behavior, avoiding the largest losses experienced when following the buy-and-hold approach, and therefore reducing the drawdown figures significantly.

DECLARATION OF INTEREST

The author reports no conflicts of interest. The author alone is responsible for the content and writing of the paper.

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